FAO Fisheries Circular No. 946 FIPP/C946
ISSN 0429-9329

HISTORICAL CONSUMPTION AND FUTURE DEMAND FOR FISH AND FISHERY PRODUCTS:

EXPLORATORY CALCULATIONS FOR THE YEARS 2015/2030

Food
and
Agriculture
Organization
of
the
United
Nations

FAO Fisheries Circular No. 946 FIPP/C946

HISTORICAL CONSUMPTION AND FUTURE DEMAND FOR FISH AND FISHERY PRODUCTS:

EXPLORATORY CALCULATIONS FOR THE YEARS 2015/2030

by

Yimin Ye
Consultant
Mariculture and Fisheries Department
Kuwait Institute for Scientific Research
P.O. Box 1638, 22017 Salmiya, Kuwait

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1999

PREPARATION OF THIS DOCUMENT

The Development Planning Service (FIPP) of the FAO Fisheries Department is the lead unit for the preparation of "The State of World Fisheries and Aquaculture", published bi-annually by the Fisheries Department. This document regularly includes a section dedicated to the outlook for the sector. Dr Ye's study of future fish consumption provides information on this section. The study is also a starting point for the Fisheries Department's contribution to the planned updating of FAO's "Agriculture Towards 2010" study.

Ye, Y.
Historical consumption and future demand for fish and fishery products: exploratory calculations for the years 2015/2030.
FAO Fisheries Circular. No. 946. Rome, FAO. 1999. 31p.

ABSTRACT

Dr Ye's study provides an estimate of global demand for fish as food in the years 2015 and 2030. Global demand is obtained by adding estimates made for 17 groups of countries. After a review of consumption during the last 35 years, Dr Ye projects demand using observed statistical relationships between *per caput* consumption (live weight equivalent) and *per caput* GDP, a choice dictated by the paucity of historical data on price. For regions where a relationship (established through regression analysis) between observed *per caput* consumption and *per caput* GDP does not have statistical significance, or leads to clearly unrealistic results, a time trend regression was used. The author presents his results grouping the 17-country groups into six continents. He ends by discussing the significance of his findings, stressing that they represent potential demand; actual demand will be determined by the supply response to prices.

The FAO Fisheries Circular is a vehicle for distribution of short or ephemeral notes, lists, etc., including provisional versions of documents to be issued later in other series.

FOREWORD

This study of global demand for food fish is the first, simple step in a sequence of activities aiming to throw light on what the future holds for capture fisheries and aquaculture. The results of the study show that the challenge confronting the sector could be dramatic: potential demand in the year 2030 may be as much as the double of the effective demand in 1995. Dr Ye estimates that about 40% of the increase in demand is caused by population increase, the remaining 60% mainly by economic growth. Given that capture fisheries on wild stocks are unlikely to significantly increase supplies during the coming decades, the pressure on existing wild resources – and the incentive for increased aquaculture production – will grow dramatically.

Results of Dr Ye’s study will be combined, in the coming year, with those of specific studies of likely development in major markets, and with a detailed review of potential increase in production which results from capture fisheries and aquaculture.

I would like to thank Dr Ye for accepting to undertake this study in spite of his busy schedule.

Ulf Wijkström
Chief
Development Planning Service
FAO Fisheries Department

ACKNOWLEDGEMENTS

This work was completed during a two-week consultancy at FAO. The report contains many important inputs and discussion results with scientists at the Development Planning Service, FAO Fisheries Department. The Service Chief, Ulf Wijkström, provided all the data required for this study. Angel Gumy and Nathanael Hishamunda are gratefully acknowledged for their valuable discussions and comments. The Fishery Information, Data and Statistics Service is also recognized for allowing the author to use its database.

CONTENTS

Executive Summary

The world as a whole made a significant progress in fishery production over the last three decades. Total production increased from 39.1 million tonnes in 1961 to 121.4 million tonnes in1996. Its fastest growth was seen in the last five years with an average annual rate of 4.5%.

Asia has been the largest fish producer. Its production reached 60.4 million tonnes in 1995, comprising 52.3% of the world production. Latin America produced 21.8 million tonnes (18.9%), followed by Europe 18.7 million tonnes (16.8%) and North America 6.5 million tonnes (6%). Oceania came last with a production of 1 million tonnes, representing 0.9 % of the world production.

The fastest increase in fishery production was seen in Asia. Over the last five years, Asia experienced an annual growth rate of 6.3%. Latin America showed a slightly lower increasing rate. Fishery production in Africa, North America and Oceania remained relatively stable. In contrast, the European production declined significantly from 21.7 million tonnes in 1990 to 18.7 million tonnes in 1995, which was caused by the drastic reduction of the Ex-CPEs' fishery production.

The world average per caput fish consumption has been growing over time. The *per caput* consumption level of 8.9 kg in 1961 increased by 78% to 15.8 kg in 1996. The last five years had the highest average annual increasing rate of 4.7%.

Average per caput fish consumption varied greatly from one continent to another. North America had the highest *per caput* fish consumption, 21.6 kg in 1995, followed by Oceania, 19.5 kg, Asia, 17.9 kg, Europe, 16.8 kg, and Africa, 7.5 kg. However, the greatest increase in *per caput* fish consumption was seen in Asia during the period of 1990 to 1995. On the contrary, Europe experienced a dramatic decrease. Other areas remained stable.

Rich countries consumed more fish than poor countries. Average annual food fish consumption per person was only 12.7 kg in the low-income food-deficit countries, but it was 19.5 kg in the rest of the world.

International trade tended to move fish products from poor to rich countries. Low-income food-deficit countries exported 4.26 million tonnes of fish, but imported only 2.37 million tonnes in 1995.

The quality of fish consumed in the low-income food-deficit countries was lower than the rest of the world. A kilogram of fish in low-income food-deficit countries provided 98.5 grams of protein. On the average, the same amount of fish in the rest of the world produced 110 grams of protein.

Fish is becoming more and more important in people's diet. The world average contribution of fish consumption to animal protein supply has been increasing in general over the last three decades, reaching 16.6% in 1996. The share of fish in total protein intake also increased over time with 6.1% in 1996.

Fishery contribution to food security should be measured by access to fishery products and by the amount consumed. Of the 34 countries where fish provided people with more than 50% of animal protein intake, most are low-income food-deficit countries. The importance of fish as a source of protein can never be overemphasized. In rich countries, however, the amount of fish consumed should be taken as a measure of fishery contribution to people's daily diet.

Worldwide potential demand for fish and fishery products will continue to grow strongly. It was forecasted at 183 million tonnes in 2030, or 95 million tonnes higher than the amount consumed in 1995. This requires an average annual increasing rate of 2.1%. Of the 95 million-tonne increase in potential demand, 60%, or 57 million tonnes, will be caused by economic development and other factors, and 40%, or 39 million tonnes, will result from population increase. This suggests that if the world average *per caput* fish consumption was fixed at the 1995 level, the total demand for fish and fishery products would be 126.5 million tonnes in 2030.

Per-caput fish demand will grow more slowly than total demand for fish. It was forecasted to grow at an average annual rate of 1.1% and reach 22.5 kg in 2030, representing an increase of 6.9 kg from the 1995 actually consumed amount of 15.6 kg.

Africa and the Near East will experience the fastest increase in per caput fish demand. Fish demand in this area will average 14.8 kg per person in 2030, representing an average annual growth rate of 2%, from the 1995 amount of 7.4 kg. The slowest growth in *per caput* fish consumption will be seen in Asia at the yearly rate of 0.85%.

The World Fish Demand Forecast is a forecast of potential demand, not a consumption forecast. The extent to which the forecasted demand can be achieved depends on whether production can evolve with the same pattern as was seen in the past.

1. INTRODUCTION

1.1 Background

The 1996 World Food Summit pledged to bring about a radical reduction in world hunger and malnutrition. To achieve this goal, relevant development strategies must be in place in various sectors of food production. The comprehensive review of world food fish consumption and exploratory forecasts of future demands intends to shed light on long-term development policies to ensure the sustainable contribution of fisheries to food security.

This report describes the new version of the Westlund's Apparent Historical Consumption and Future Demand for Fish and Fishery Products model (Westlund 1995). It includes a discussion of the evolution, philosophy, and basic structure of the demand forecast model. It is anticipated that the demand forecast model will continue to evolve over time, not only as a reflection of ongoing efforts to refine the behavioral equations of the model, but also to incorporate changes in the core set of countries and country groups.

1.2 Objectives

The primary objective of this study is to carry out preliminary medium- and long-term forecasts for the global demand for fish and fishery products. The objective is to foresee the demand pressure and consequently to highlight the necessary actions required for a secure supply of fish and fishery products in the future. The main outputs of this study are world and regional demands, regional differences in demand in comparison with supply, and possible development of international trade of fish and fishery products.

1.3 Data used

The main historical data used in this study are annual fishery production, consumption of fish and fishery products, population and Gross Domestic Production (GDP). Population data are from the United Nations' 1996 assessment (medium variant), GDP statistics and projections are the World Bank 1998 data, and the fishery related data were derived from the "Fish and Fishery Products—World Apparent Consumption Statistics Based on Food Balance Sheets (1961-1995)" compiled by Laureti (1998), Fishery Information, Data and Statistics Service of the Food and Agriculture Organization.

This study focuses on fish demand and consumption of human population, and thus excludes the amount of fish production used for non-food purposes. Marine mammals and aquatic plants were not included. Therefore, consumption or demand of fish and fishery products in this study refers only to human consumption or demand. It was defined as in the food balance sheets (Laureti 1998) that a country's food fish consumption is equal to production minus non-food uses plus/minus stock changes plus import minus export. When some inconsistent *per caput* fish consumption is seen in other publications, this definition should be kept in mind.

All the figures on fish production and consumption are in live weight equivalent. It should be remembered that such a measurement is different from the true volume actually consumed by people. This is because different types of fish, for example finfish and shellfish, yield quite different amounts of edible flesh.

1.4 Regional aggregation

Fish consumption is related to many natural and social factors, such as natural environment, social culture and tradition, living standards and availability of substitutes. There are over 200 countries and regions around the world. All the factors mentioned above vary significantly from country to country. Developing a fish demand model for each country is unwieldy and also difficult to maintain. It was then decided to adopt a group structure. Geographical relation was first considered. Fish consumption habit was also a major factor taken into consideration. The more homogeneous the country group, the higher the similarity of fish consumption and demand. Therefore, in this study, the world was divided into seventeen country groups (see Annex I). Country groups were summed up to six continental groups, Africa and the Near East, Asia, Europe, Latin America and the Caribbean, North America, and Oceania, and finally the global fish production and consumption are the summation of the continental groups.

2. HISTORICAL DEVELOPMENT

2.1 Fishery production

The world total fish production kept increasing, achieving a record high of 121 million tonnes in 1996. Although there was a steady general increasing trend since the early 1960s, the fastest increase in fish production was recorded in the last five years from 1991 to 1996 (Figure 1).

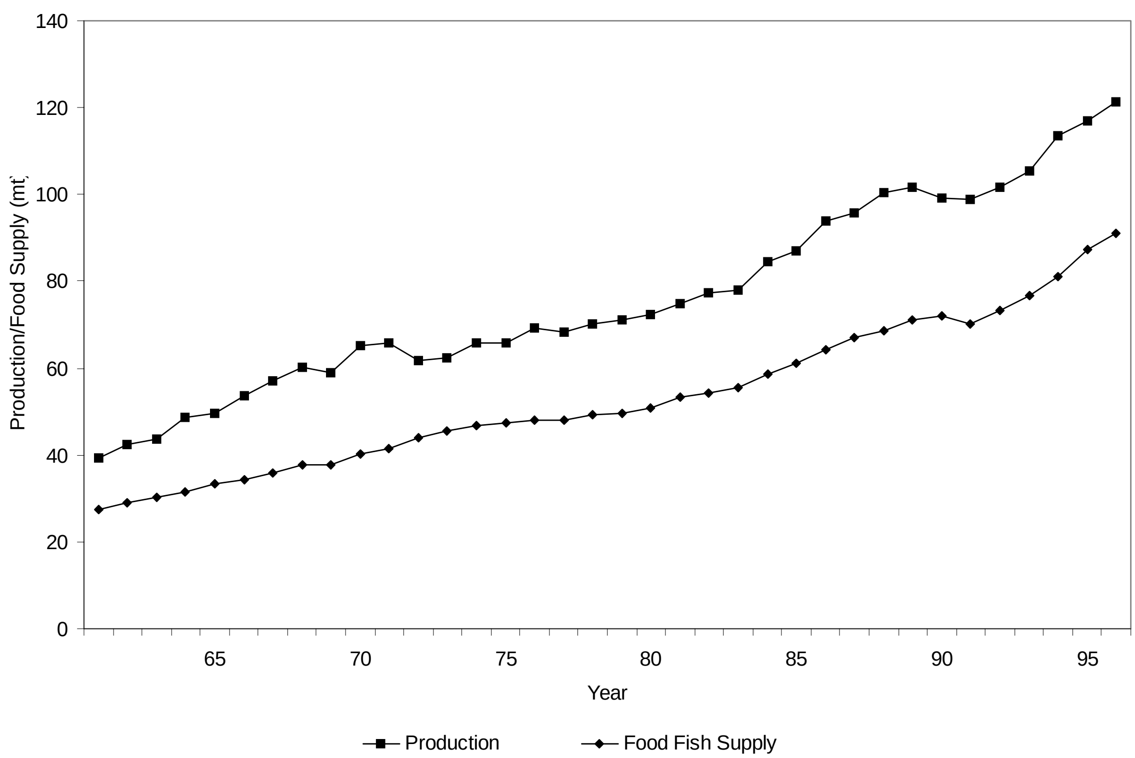

Figure 1. World fishery production and food fish supply

Among the various regions, Asia has remained the largest fish producer. Its production has been increasing over time. In the 1960s, the production of Asia was only slightly higher than the second largest producer, Europe. By 1995, however, Asia's production was 3 times as high as the European production, reaching 60 million tonnes in 1995 (Figure 2).

Latin America exceeded Europe slightly, having about 20 million tonnes in 1995. North America produced as much as Africa and the Near East did, about 7 million tonnes. Oceania came last only about 1 million tonnes in 1995 (Figure 2).

Although there was a steady increase in world total production since the early 1960s, regional differences in the development of fish production were quite significant. The fastest development was seen in Asia. Europe had a similar increasing trend to Asia's from 1961 to 1975. Afterwards its production stagnated, probably due to the introduction of Exclusive Economic Zones, and started to decline in 1987. This decline might be attributed to the economic collapse in the Ex-Centrally Planned Economies (Ex-CPEs) of the former Soviet Union and East Europe.

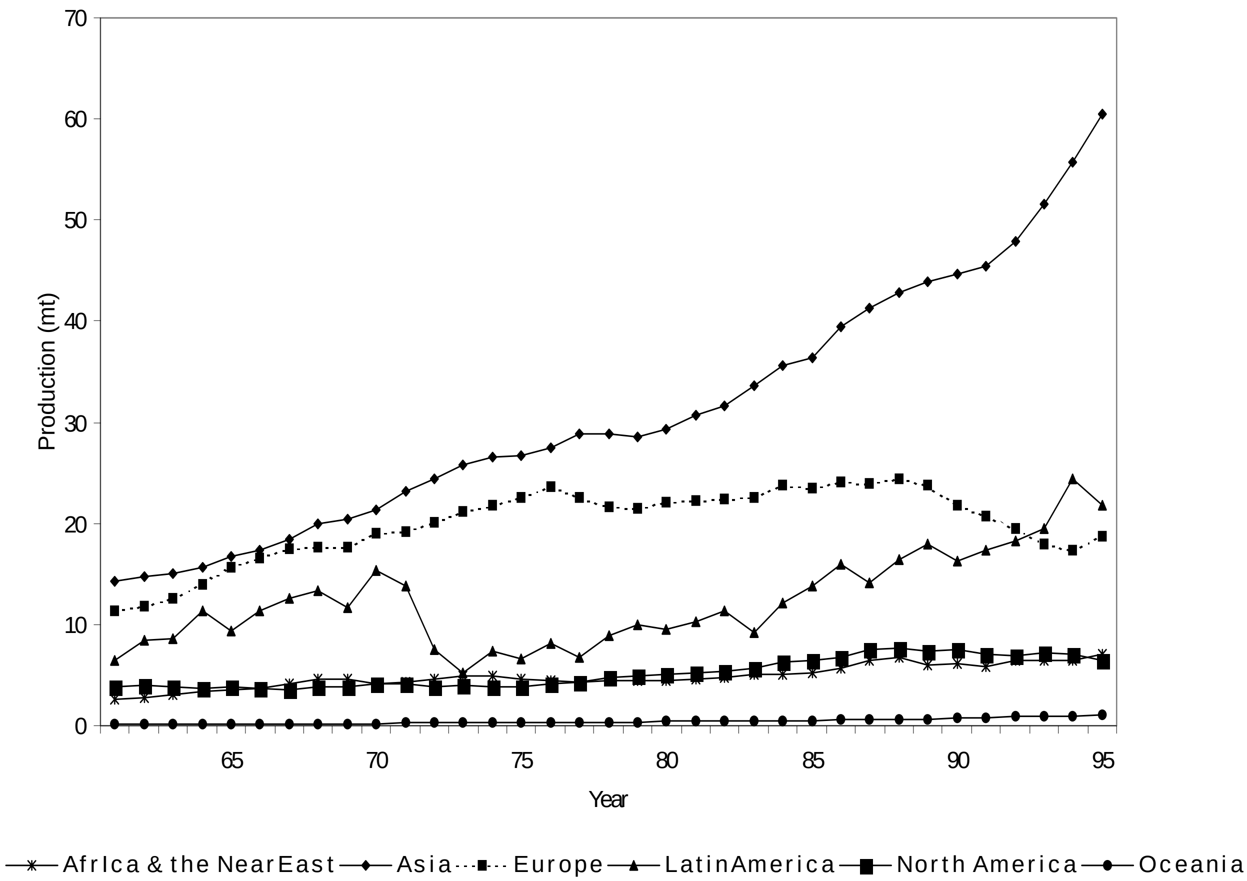

Figure 2. Fishery production by continental group

Latin America and the Caribbean also exhibited a similarly rapid growth in its production before 1970. A sharp drop, however, occurred in the early 1970s due to the collapse of the Peruvian anchovy fishery, which even made the world total fish production decline in 1972 (FAO 1997). Fish production in Latin America and the Caribbean recovered gradually afterwards, achieving more than 20 million tonnes in 1995. Other continents showed a gradual increase in general (Figure 2). It is noteworthy that the total production of Latin America and the Caribbean showed an exceptionally high variability from year to year. This was because its bulk of production was from pelagic species, the abundance of which was highly affected by variable natural environment.

Besides continental differences in fishery production, there were also important and significant differences among country groups. Fish production in Asia as a whole increased most rapidly over the last five years, by 35% from 1990 to 1995. However, Japan experienced the most drastic decline of fish production in its history. Its total production was only 6.78 million tonnes in 1995, representing about 35% reduction in comparison with 1990 (Figure 3). This was partially caused by its setback in distant-water fisheries. Japan had the largest distant-water fishery around the world in 1996 with a total catch of 0.688 million tonnes. But, this was Japan's lowest figure since 1963, as the country's distant-water fishery production has declined steadily since the early 1970s when a peak of 2 million tonnes was achieved (FAO Fisheries Department 1998).

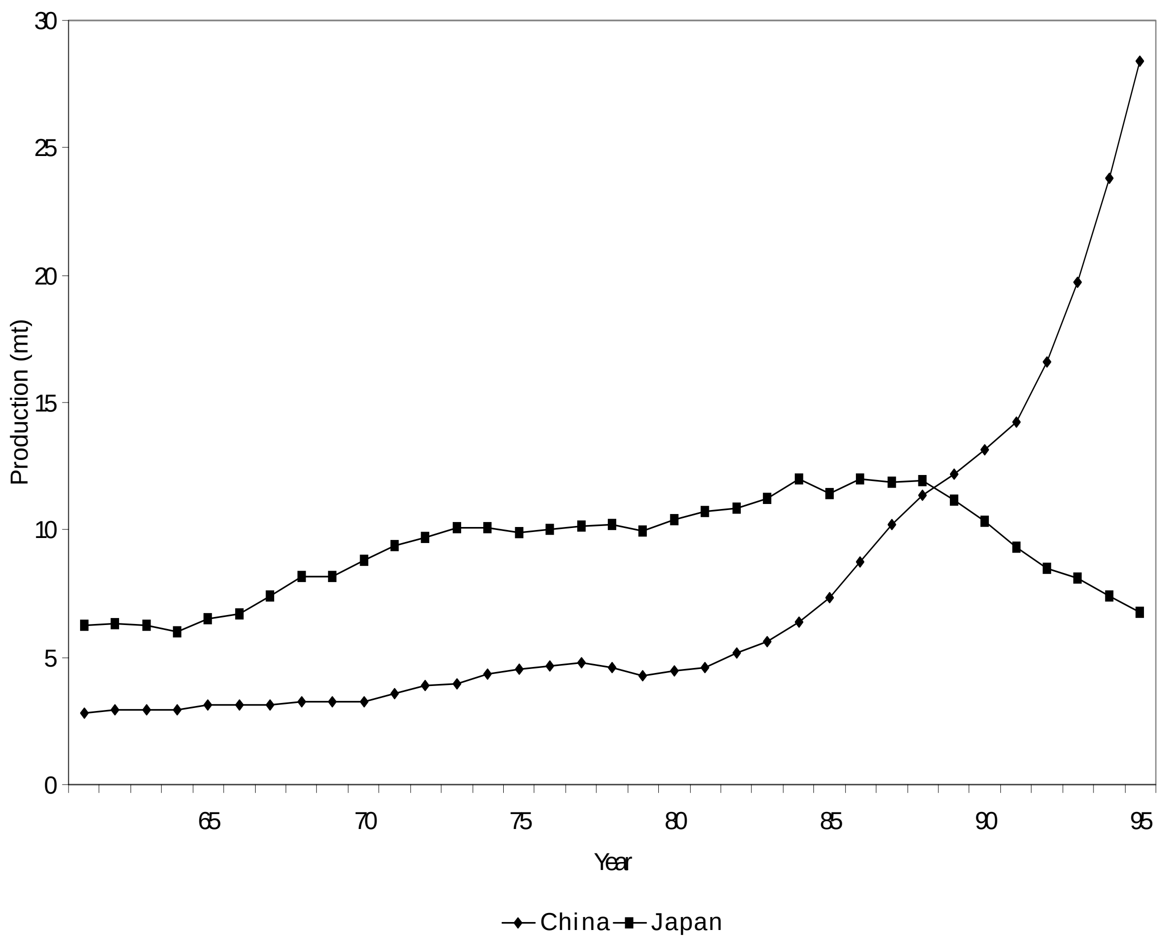

Figure 3. Fishery production in China and Japan

The biggest contributor to the increased fish production in Asia was China. The Chinese fishery production increased by 116% from 13.1 million tonnes in 1990 to 28.0 million tonnes in 1995 (Figure 3), constituting about 24% of the world total production. Such a great increase was the only one of its kind in fisheries. At the regional level, the effects of the Chinese fishery had overshadowed all other variations that happened in the rest of Asia.

Although the European total fish production declined since 1988, both Nordic countries and the Western Europe had quite stable productions since the late 1960s. Only the production in Ex-CPEs decreased dramatically from a peak of 12.4 million tonnes in 1988 to a bottom low of 5.1 million tonnes in 1994, with a slightly recovery in 1995 (Figure 4).

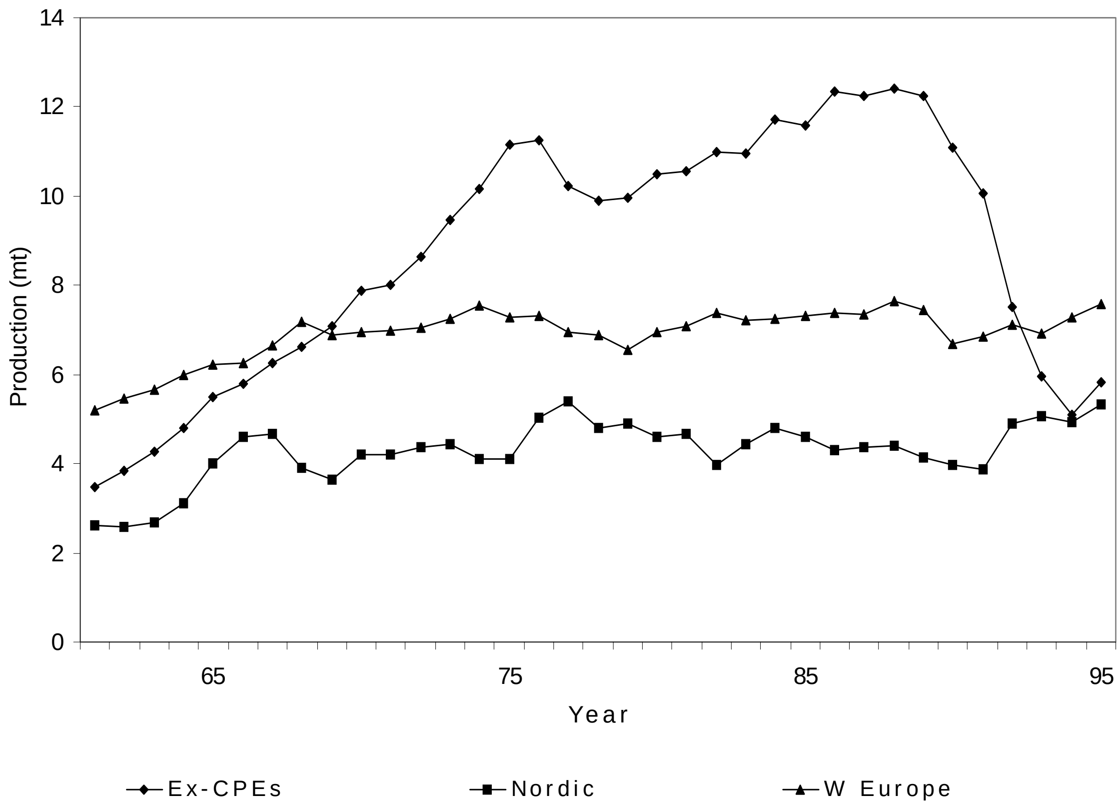

Figure 4. Fish production by country group in Europe

2.2 Non-food uses of fishery production

Of the total fish production, some was used for non-food purposes, mainly for reduction to fishmeal and oil. The percentage for non-food uses reached a record high of about 40% in 1970, and then dropped sharply. This variation in percentage was highly coincidental with the collapse of the Peruvian anchovy fishery in the early 1970s. The proportion of fishery production for non-food uses remained rather stable since then and slid downward a bit over the last five years, falling to 25% in 1995 (Figure 5). The percentage of fishery production used for non-food purposes has been significantly influenced by the stocks of small pelagics in the Eastern Pacific. The decreasing trend over the last few years may also be attributed to technical development in processing industry that was pushed by high demand for fish (Ahmed 1997). Some fish species that were not edible before became consumable for human. The percentage is anticipated to decline further in the future with the rapid increase in fish demand for human consumption.

2.3 Fish consumption

The world food fish consumption increased with a similar trend to the world fishery production, attaining 86.3 million tonnes in 1995 (Figure 1). After a decrease in 1990-1991, food fish consumption recovered rapidly with an average annual growth rate of 8.4% over the last five years.

Asia was the largest food fish consumer, 61 million tonnes in 1995. Europe was ranked second with a consumption of about 12 million tonnes. North America and Oceania consumed a similar amount of 8 million tonnes. Latin America and the Caribbean came last with about 5 million tonnes (Figure 6).

Regional developments of fish consumption were quite different. Asia showed the most rapid increase, particularly in the last five years. North America, Latin America and the Caribbean, and Oceania all exhibited a gradual-increasing trend. Europe was the only region that experienced an apparent decline after 1991 (Figure 6). This decline was mainly caused by the decrease of fish consumption in the transition economies.

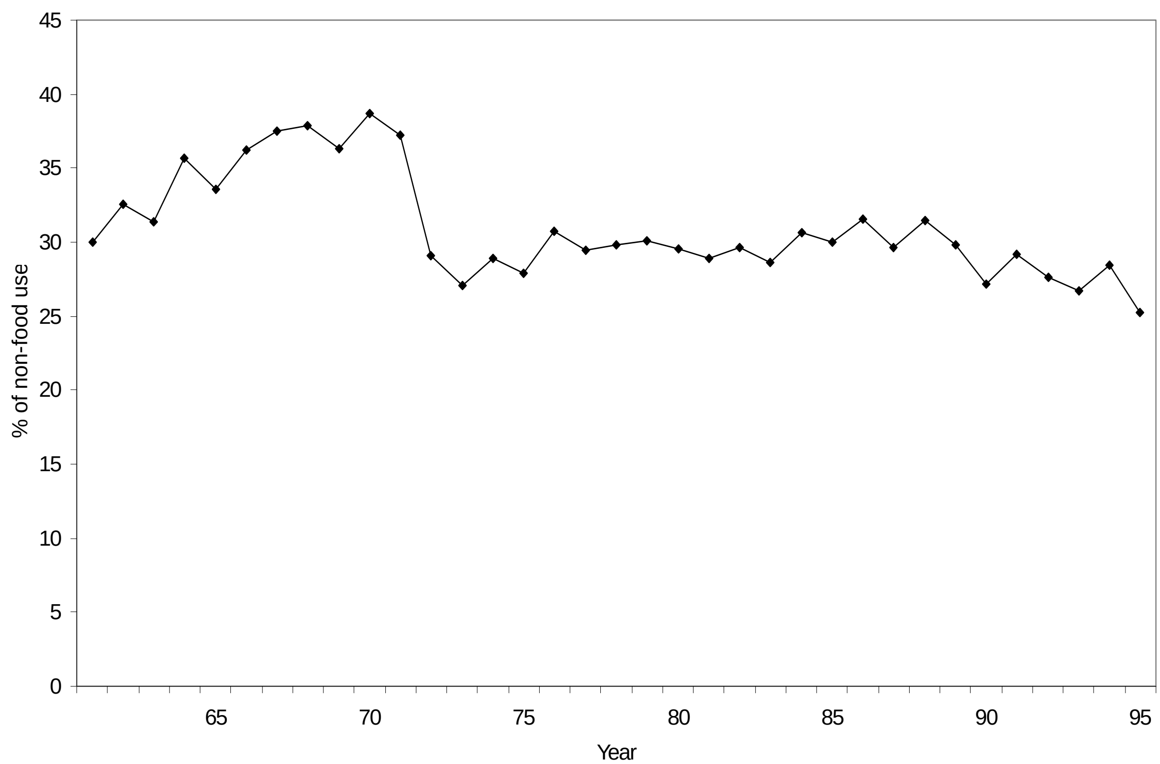

Figure 5. Historical variation in percentage for non-food uses

The apparent world average *per caput* food fish consumption increased further and attained 15.8 kg in 1996. Although a drop in *per caput* fish consumption was observed in 1990, the last five years showed the highest average annual increasing rate, 4.7% (Figure 7).

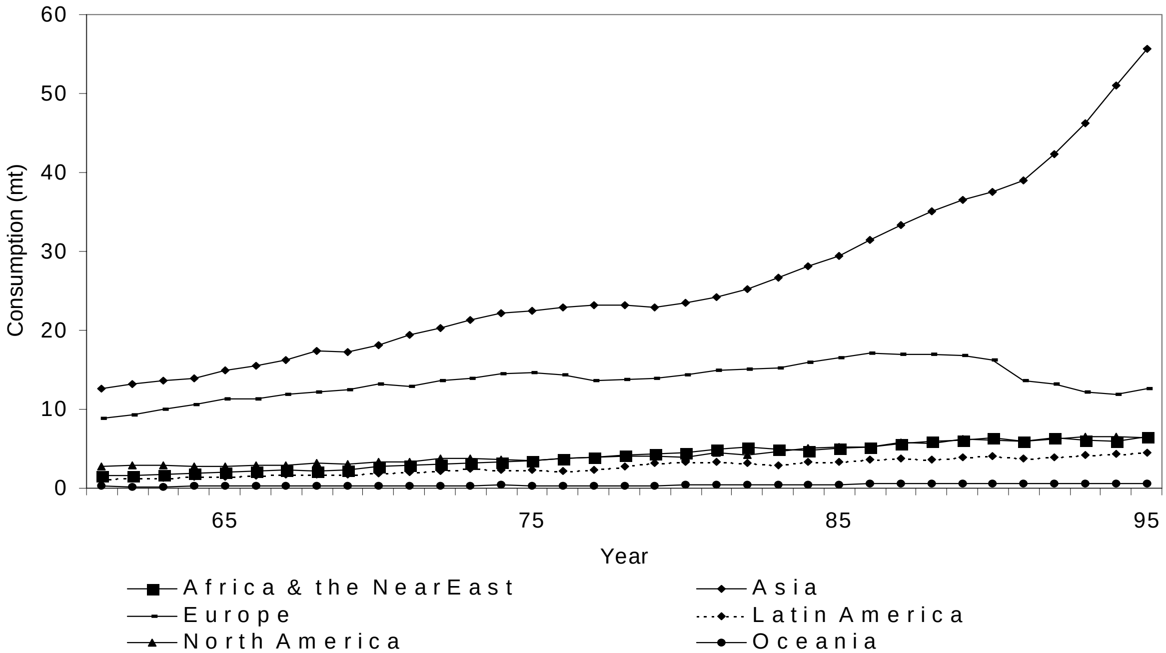

Figure 6. Fish consumption by continental group

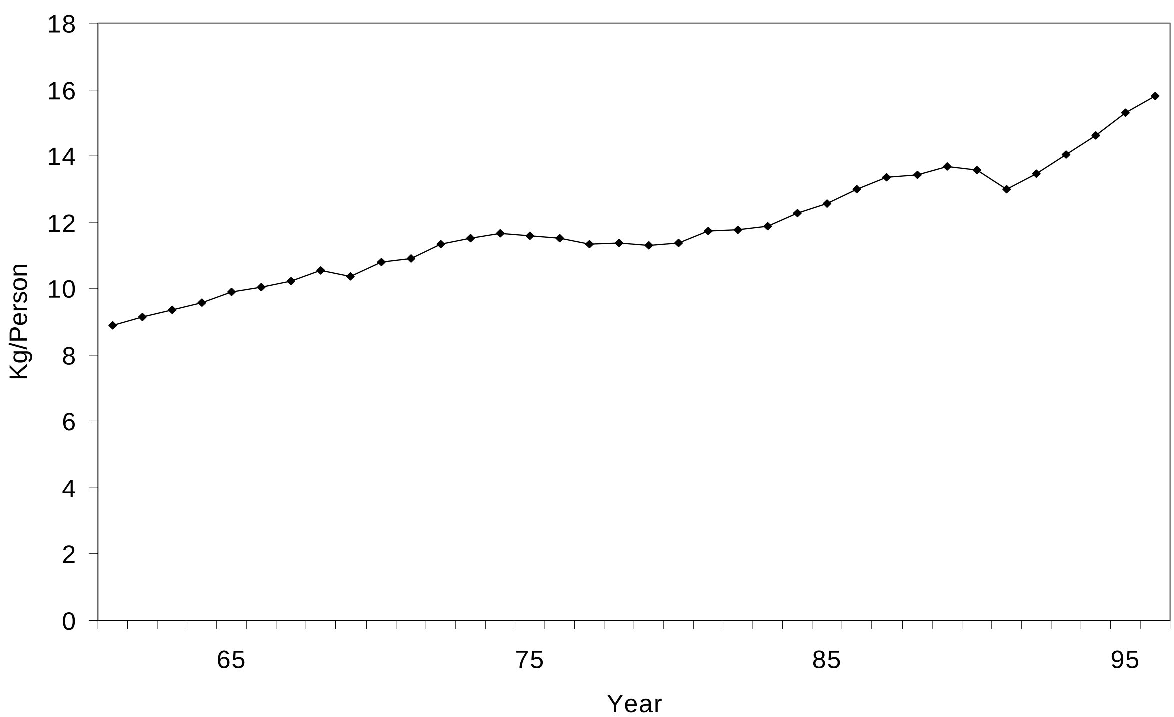

Figure 7. World average *per caput* fish consumption

There were significant differences in *per caput* fish consumption among continental groups (Figure 8). Europe had the highest *per caput* fish consumption before 1990, but experienced a drastic decline since then. In contrast, Asia exhibited the fastest increase over the last five years. Fish consumption in other continents did not change very much. By 1995, North Americans became the largest fish consumers, 21.6 kg per annum. They were closely followed by oceanic countries with a *per caput* consumption of 19.5 kg. Asia exceeded Europe, becoming the third largest fish consumer with 17.9 kg per capita, a slightly higher consumption compared to Europe's (16.7 kg). Latin America, Africa, and the Near East had the lowest *per caput* fish consumption, or 9.5 kg and 7.4 kg, respectively, in 1995 (Figure 8).

At the aggregation level, differences among countries could not be easily identified. In fact, fish consumption also varied significantly from one country to another. There were some general characteristics to be drawn.

- Island and coastal countries usually had a higher *per caput* food fish consumption compared with inland countries. Table 1 lists the countries where people consumed more than 50 kg per person per year, more than 3 times as high as the world average 15.8 kg in 1996. Most of the 23 countries and regions were small islands or coastal countries. The surrounding oceans and seas provided those countries with the most accessible and cheapest protein sources.

- The level of *per caput* food fish consumption in a country or region was largely determined by availability. Large producers of fish and fishery products were usually also high fish consumers. For example, Japan was one of the largest fish producers and the largest fish consumer. Its *per caput* fish consumption was 70.9 kg in 1995. Norway was another example with a *per caput* consumption of 50.4 kg in 1995. Although as a European country, fish protein constituted only 24.2% in total animal protein supply, Norway's *per caput* fish consumption was much higher than other European countries'. This was because Norway's abundant fishery resources produced 2.8 million tonnes of fish and fishery products with 1.85 million tonnes exported. In contrast, low production had also limited fish consumption. *Per caput* consumption was below 2 kg in Ethiopia, Eritrea, Burkina Faso, Niger, Lesotho, Rwanda, Sudan and Swaziland. Poor economic conditions did not allow them to import fish.

- Fish consumption in most countries has been growing with economic development and improvement in fish availability. China serves a good example for this purpose. Over the last two decades, China's economy developed dramatically with a 4-fold increase in GDP. Economic improvement raised consumption demand for fish and fishery products and, in return, stimulated fishery production. The Chinese fish production increased more than 6 fold from 1975 to 1995. *Per caput* consumption consequently grew from 4.8 kg to 22.5 kg.

- Rich countries consumed more fish than poor countries. Although fishery production development in the low-income food-deficit countries resulted in a continued increase in *per caput* fish consumption, it was only 12.7 kg in 1995, still much lower than the 19.5 kg in the rest of the world (Laureti 1998).

- International trade tended to create a flow of fish products from poor to rich countries. Low-income food-deficit countries exported 4.26 million tonnes of fish, but imported only 2.37 million tonnes in 1995, a difference of 1.89 million tonnes. The volumes of import and export were derived from the summation of each country's statistics of imports and exports.

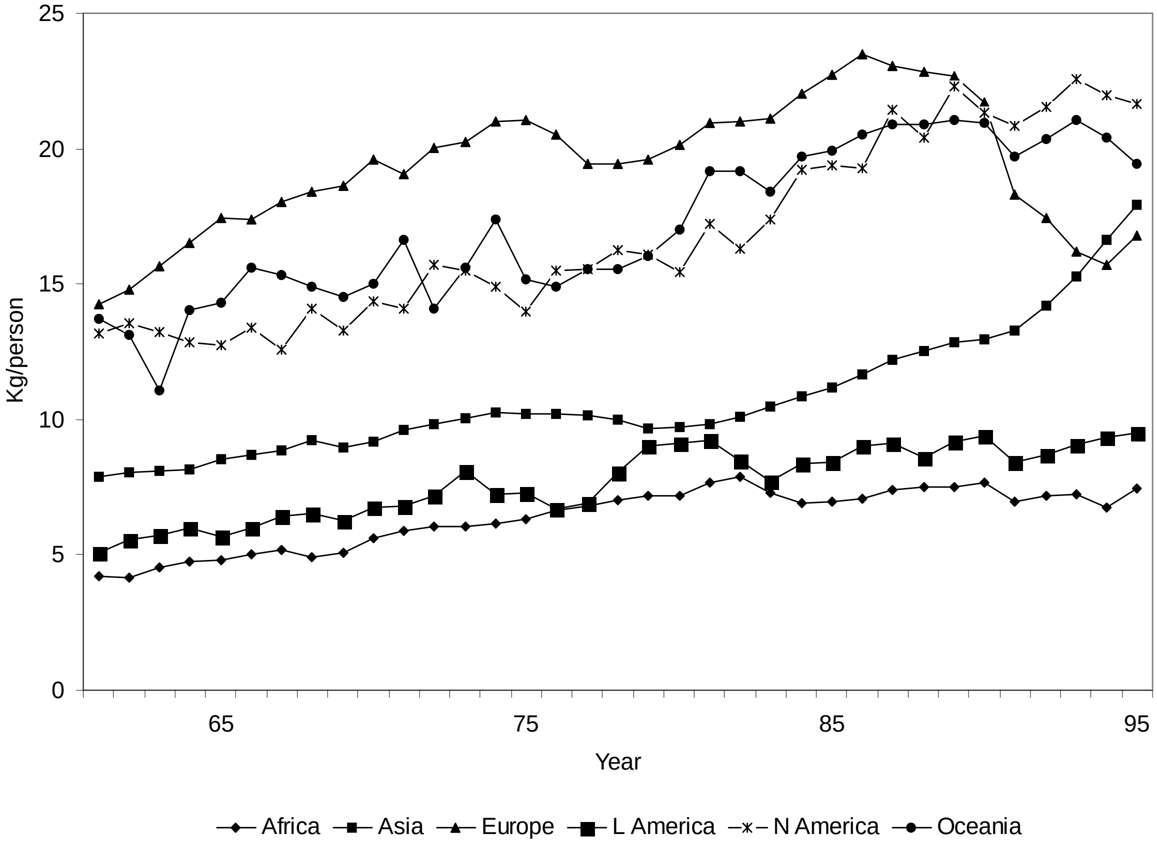

Figure 8. *Per caput* fish consumption by continental group

Table 1. Countries where people consumed more than 50 kg of fish per annum

Africa & The Near East

Saint Helena
Seychelles
Tokelau

Asia

Hong Kong
Korea Republic
Japan
Malaysia
Maldives

Europe

Faeroe Islands
Norway
Portugal

Latin America and The Caribbean

Antigua and Barbuda
British Virgin Islands
Guadeloupe
Martinique
Falkland Islands

North America

Greenland
St Pierre and Miquelon

Oceania

Cook Island
French Polynesia
Kiribati
Niue
Palau

Thus, the result does not necessarily mean that all exports from low-income food-deficit countries were absorbed by the non low-income food-deficit countries. Trade took place among low-income food-deficit countries. However, the large negative difference between total imports and exports of this country group means that international trade increased the supply of fish to the rest of the world.

- In general, the quality of fish consumed in the low-income food deficit countries was lower than that in the rest of the world. Calculated from the food balance sheets, 1 kg of fish consumed in the low-income food-deficit countries provided only 98.6 grams of protein, while it provided 110 grams of protein in the rest of the world. This may be explained by the incentives of poor countries to earn hard currency by exporting high quality fish or fishery products that were highly pursued in developed countries (Ahmed 1997).

2.4 Fishery contribution to food security

Fish, as food is a source of high quality protein. It is rich in micronutrients that are generally not found in staple foods. Fish can also provide with important preformed vitamin C and D, if its oil is consumed, iron, phosphorus and calcium (Kent 1987). Marine fish is a good source of iodine. Fishery products also contribute fatty acids that are necessary for proper development of human brain and body. Fatty fish is high in polyunsaturated fatty acids that keep blood cholesterol levels low and prevent cardiovascular diseases (Kent 1987).

Fish has many unique nutritional values in comparison with other animal protein sources. Awareness of nutritional values of fishery products is rising around the world, particularly in developed countries where more and more people take fish as a healthy food and favor for increasing consumption of seafood.

The world average contribution of fish consumption to animal protein intake has, in general, been increasing and reached 16.6% in 1996 (Figure 9). The share of fish in total protein supply also showed a general increase since 1960, attaining 6.1% in 1996. The ever-increasing share of fish in animal protein intake and total protein supply implies that fish has been becoming more and more important in people’s diet.

Of the various continental groups, Asia had the highest fish share in animal protein and total protein intakes, 26.3% and 7.4 %, respectively, in 1995. The second was Africa in which fish contributed 17.4 % to animal protein supply. North America, Latin America, Europe and Oceania had similar percentages of fish protein in animal protein supply, ranging from 7.2% to 9.3% in 1995. It can be concluded that Asia and Africa were more fish favored, and the rest continents were more meat oriented. This kind of consumption pattern has been determined by tradition and availability of various foods.

The contribution of fisheries to food security should be measured by access to fish products and by the amount consumed. In general, the diets of richer countries seem to be more balanced nutritionally and also contain a greater proportion of protein, particularly of animal protein, than those of the poorer countries. Developing countries’ diets are characterized by a high proportion of cereals (FAO 1998). Absolute fish consumption does not necessarily indicate its importance in food security and nutritional contribution.

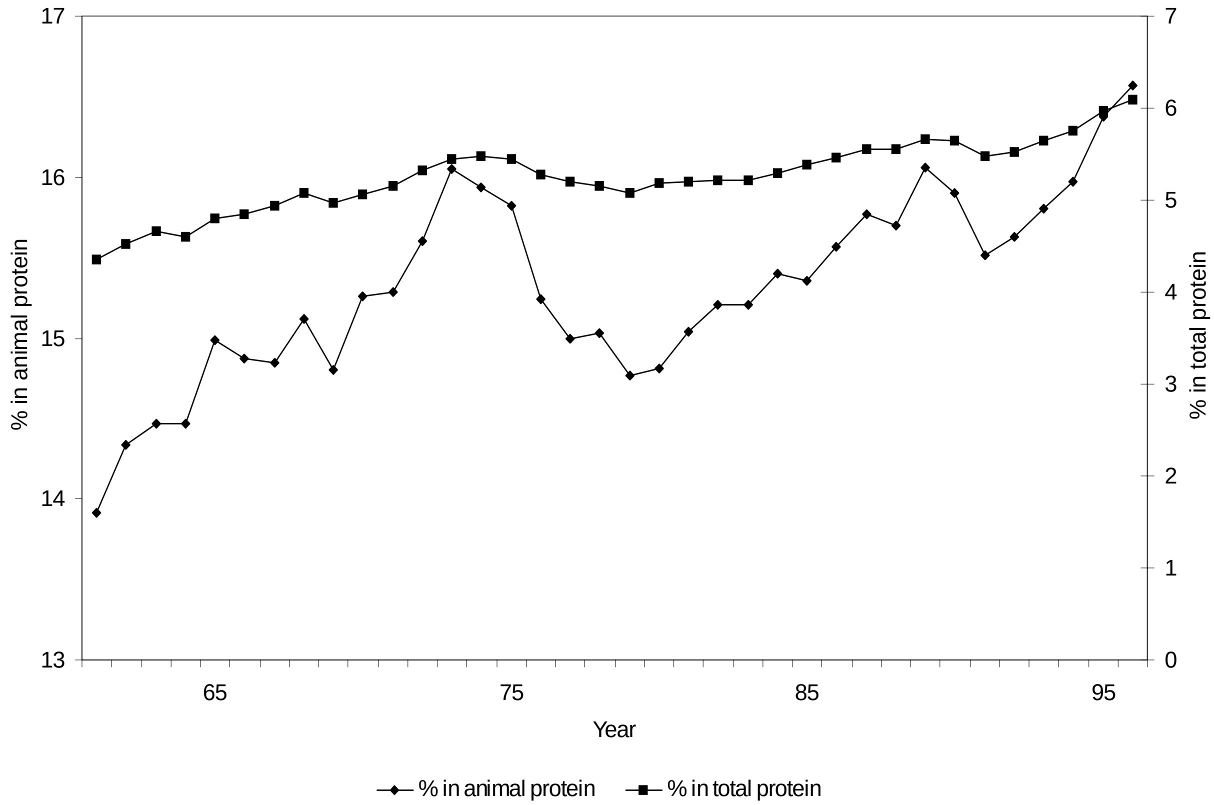

Figure 9. Percentages of fish protein in animal protein intake and total protein fish supply

There were 34 countries where fish provided more than 50% of animal protein intakes (Table 2). There are two factors that determine fish consumption. One is availability. Most countries listed in Table 2 are low-income food-deficit poor countries that are located in small islands. The high percentage of fish protein in their diet resulted from the fact that fish is the most natural protein source available to them. For them, fish might be the cheapest food they could afford and also the easiest they could obtain.

Cayman Islands is an extreme example. Fish protein constituted 99.6% of their animal protein intake and 99.4% of total protein supply in 1995. However, its absolute protein intake was only 10.8 grams *per caput* per day, representing only less than 10% of the United State's and 15% of the world average. The contribution of fish and fishery products to food security in such a place can never be overemphasized.

The other factor is economic purchase capability. With the awareness of fish nutritional values, people's consumption may switch to fish or fishery products if they can economically afford it. Japan serves as a good example for this purpose. *Per caput* fish consumption in Japan was 70.9 kg in 1995, constituting 55.2% of its animal protein intake and 26.6% of total protein supply. The Japanese consumers' preference of fish and fishery products over other sources of animal protein resulted from a long history and diet tradition. Their fish consumption desire was backed by their high purchasing power. In 1995, the Japanese fish production shrank by 34% in comparison with 1990. However, *per caput* fish consumption remained unchanged. This was materialized by reducing fish export and increasing fish import with the support of economic power.

Table 2. Countries where fish protein constituted more than 50% of animal protein intakes*

Africa & The Near East

Cape Verde
Comoros
Congo, Republic
Equatorial Guinea
Ghana
Guinea
Malawi
Saint Helena
Sao Tome and Principe
Seychelles
Sierra Leone

Asia

Bangladesh
Cambodia
China (Taiwan province)
Indonesia
Japan
Korea, Dem. Rep.
Korea, Rep.
Maldives
Myanmar
Philippines
Sri Lanka
Viet Nam

Europe

Faeroe Islands

Latin America and the Caribbean

British Virgin Islands
Cayman Islands
Greenland
Guadeloupe
Guatemala
Guyana

North America

Oceania

Kiribati
Solomon Islands
Tokelau
Tuvalu

* In some countries, fish protein may not still constitute more than 50% now, but they did in history.
* Those underlined are low-income food-deficit countries.

3. FUTURE DEMAND FOR FISH AND FISHERY PRODUCTS

3.1 Methodology

3.1.1 Model Specification

The factors that can be expected to affect fish consumption include disposable income, price of fish, prices of fish substitutes such as meat, prices of fish complements such as rice, and non-price factors such as tastes. An analysis of the respective roles of these factors would require a huge set, fairly long time series data. In fact, of these factors, price of fish and disposable income are the most important, and also easy to quantify. Most demand analyses in econometric literature, therefore, concentrated on estimating income and price elasticities (DeVorentz 1982, Bird 1986, Ye 1994, 1996a; Delagado and McKenna 1997).

A fundamental part of the market demand theory is that market clears by changing price. Market price is a lever between demand and supply. When a commodity is in high demand, price will go up. The increased price consequently stimulates production while depressing market demand. The increase in production directly leads to improved market supply and then exerts negative effects on price in return. The two sides of the market interact gradually towards equilibrium between demand and supply. The actual quantity of a commodity consumed is therefore the intersection between demand and supply.

The production system of fish and fishery products has some unique characteristics. Consumption of fishery products usually is predetermined (Bird 1986, Ye 1994, 1996a), which is very different from industrial commodities. For perishable fish, production is very nearly equal to domestic consumption (Fox 1992). Production is thus a variable determined, independently of the price of fish, by natural and economic factors, particularly for capture fisheries. Price has no immediate effects on production, but may positively influence the production of the following years (Ye 1994, 1996a). Given production, fish market clears finally by adjusting price, i.e. price can be expressed as a function of production (Huang 1988, Fox 1992). Consumption is finally determined only by production. A high correlation between fish consumption and production can often be demonstrated with the historical observed data. Unfortunately, this kind of relation is not useful for demand forecast because demand forecast may not be meaningful any more if production in the future can be foreseen.

Fish consumption in this study means the total amount of fish and fishery products consumed. In reality, fish products are highly diversified. There are many species of edible fish. Each species differs significantly from each other in terms of taste, price, production volume and production location. As a study of demand at the world level, it is impossible to analyze each species for each country. All kind of fish and fishery products were treated as a composite commodity in this study. This kind of aggregation might cause series homogenous problems. Some studies, however, found that demand analysis at a certain aggregate level could be more reliable because of the close interactions between species and the deficiencies in the data for individual species (Bird 1986). The level of aggregation should still be a concern and found out by trial and error.

The difficulty in demand analysis at aggregate level is the definition of price. Normally, a general price index derived from species prices weighted by their volumes should be established. Unfortunately, information on price trends for locally consumed fish and fishery products is difficult to obtain. In the national statistics of individual countries, price indices for different food products are hardly available. Some countries, particularly the developed countries, do have price statistics. But, they are not available in the FAO database and it is impossible for this study to use. Therefore, this study proceeded in the absence of price data.

The other factor that closely affects fish consumption is disposable income. Direct indices of disposable incomes of individual countries are also not available. At the best, Domestic Gross Product (GDP) was used as a proxy for disposable income.

Economic growth is arguably the most important driver of market demand. In general, economic growth will have some positive effects on disposable incomes, although it may not be direct or may not be significant in some cases. With increased disposable incomes, people's purchasing power is then expected to rise, and more money will be expended on food. Consequently, demand for fish and fishery products rises with the increase in GDP. It is noteworthy, however, that disposable income may not change proportionally with GDP, particularly in the countries where the gap between the poor and the rich is large. This replacement of disposable income with GDP may become the reason for the difficulties to establish an unbiased relationship between fish consumption and GDP, which was encountered in this study.

With the constraints of data availability, the World Fish Demand Model (WFDM) was left only with *per caput* fish consumption and *per caput* GDP for each individual country. As mentioned earlier, there are so many factors affecting fish consumption, and GDP has positive effects only when production responds positively to the increase of commodity prices. A demand model with only one explanatory variable is definitely oversimplified. Although simplicity is an attractive characteristic for forecasting and makes it easier to comprehend, there is a very high risk when such a model is used to forecast demand, particularly into the future for as far as 30 years. Simple relations of this kind should not be explained as causal. The unique feature of fishery production-marketing system, i.e. consumption is predetermined by production, combined with the model simplicity may lead to a dilemma that cannot be explained by econometric theory.

For example, the Near East area experienced a continuous decrease in GDP over the last decade. Fish consumption, however, increased dramatically due to the increase in production caused by favorable natural conditions. A simple regression of fish consumption against GDP showed that fish consumption declined with the increase in GDP. This means that fish was an inferior good in this area. This conclusion is against many existing studies (Bell 1986; Ye 1994, 1996a, 1996b). Actually, fish consumption in this area was very low, only 6.4 kg per person in 1995. Historically, this was a net fish-import area. The low fish consumption level was caused by the limited supply. With increased production, fish consumption then consequently increased. Fish consumption was therefore determined by production rather than by GDP.

The simple relation between fish consumption and GDP is highly risky as a forecasting model because such a relationship could be established by coincidental time series data and can break if fish production is limited by natural reasons. China's economy developed rapidly over the last two decades. Fish production also increased six fold, partially because of the development of economy and partially because of the change in fishery management system. The increasing trend in both GDP and fish consumption resulted in a statistically significant relationship. If this relationship were used to extrapolate the Chinese fish demand in 2030, *per caput* consumption would be forecasted at the level of 210 kg, a figure no body would expect. This nonsense result was caused by the non-causal relationship. If price information were available, the scarcity of a commodity would be reflected by price. When GDP increases, price will go up. Fish production, particularly natural fishery is to a great extent determined by natural environment. With the limit of natural capacity, price will hike to balance demand with supply. Of course, a forecast of price, which is also a very difficult task, is first required for projecting the future demand for fish.

The data limitation compelled this study to use oversimplified models between fish consumption and GDP. When sensible results could not be achieved, time trend regression was instead used. In fact, time trend may be thought as a combined consequence of many factors mentioned above. The trend will hold if there are no structural changes in the system. As a common forecasting method, time trend forecasting is used when no detailed data are available and most often for short term purposes. In contrast, econometric model is a causal method and highly data demanding.

3.1.2 Basic assumptions

Economic growth. As GDP was used as the only explanatory variable for fish consumption, forecasts of GDP must be made before any future demand forecast for fish and fishery products. Economic growth varies greatly from one country to another. A reliable forecast for each country requires a lot of inputs of manpower, research funds and technique development, and is beyond the scope of this study. Being a fish demand model, WFDM treats the macroeconomy largely exogenously. GDP forecasts are then from the Economic Statistics Department, the United Nations.

The recent economic crisis in Asia, Russia and South America is throwing a shadow over future economic prospects. The most visible effects are sharp falls in exchange rates and share prices in the countries affected. The immediate concern is that the stability of the world economy could be affected by these events. The underlying problems and their solutions may be much longer-term. Although it is still uncertain about how long it will take for confidence in the relevant regions to return, how low economic activity might fall during this period and what the economic growth rates will eventually be, FAO’s outlook assumed that the economic difficulties experienced in Asia, Russia and South America will not reduce the long-run economic potentials of these areas. The recent difficulties are therefore viewed as altering the short-term path of economic growth and fish demand. This study concentrated on long term forecasts, and the economic crisis is unlikely therefore to significantly alter the fish demand forecast for the years of 2015 and 2030.

Population. Population was indirectly incorporated in WFDM by *per caput* fish consumption and *per caput* GDP in this study. The population forecasts for individual countries are based on the latest United Nations’ population projections. Three scenarios were available, high variant, medium variant and low variant. This study used the medium variant forecasts.

In October 1996, a downward revision was made due to the lower population growth rates experienced, particularly for Asia that accounted for a reduction of about 100 million in the revised projections (FAO Fisheries Department 1998). In general, a slower population growth will reduce the pressure on fish demand. Such a decrease in population growth rate will have a persistent effect on the level of world population in future. Any further revision in the future will also request a corresponding change in the demand forecasts for fish and fishery products.

GDP and population were the two input variables for the forecasts of fish demand. Both were treated as exogenous in this study. As these two variables were also forecasted based on other models, their accuracy would consequently impact the accuracy of demand forecasts for fish and fishery products.

3.1.3 The world fish demand model

The world fish demand model (WFDM) uses 17 regional models[1], which are further aggregated into six continents as Figure 10 demonstrates. WFDM is mainly a region-based model.

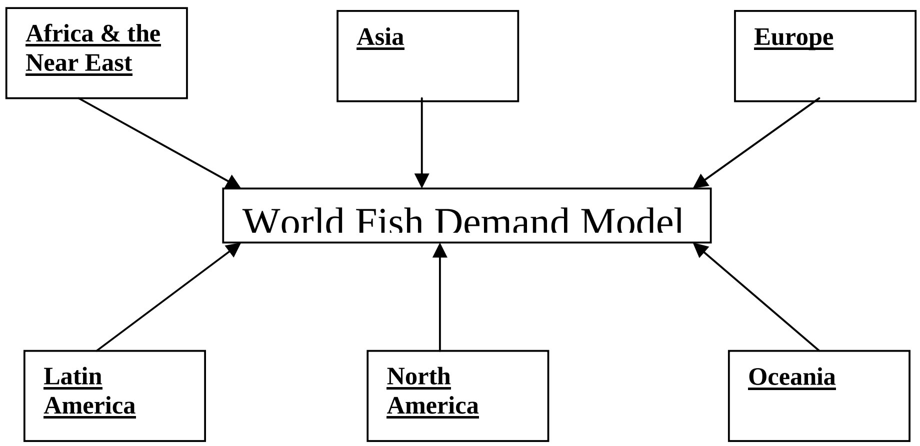

Figure 10. The structure of World Fish Demand Model (for the list of countries in each region see Annex I)

First, *per caput* fish consumption and *per caput* GDP were averaged over each region or country groups, based on the historical consumption and GDP for each country, by dividing the regional total consumption and GDP with corresponding regional population. Second, a model was built for each region. Third, the *per caput* fish demand forecast for each region were then calculated back to total demand, and summed up to the regional total. The *per caput* fish demand in a continental group was derived from dividing the total demand by the continental population. Finally, world average fish consumption per person and total demand was calculated in the same way.

All models for each country group are listed in Table 3. Some are regression equations of *per caput* fish consumption against *per caput* GDP, and others are time trend regressions. The others are a combination of the two. The statistics of each equation are also included in the table. Logarithm transformation was used for some models, depending on its statistical improvement.

3.2 Results from WFDM

The world total demand for fish and fishery products was forecasted at the level of 183 million tonnes in 2030. This amount is 95 million tonnes higher than the 1995 world fish consumption,

[1] Indian Ocean, Near East, North Africa, Sub-Saharan Africa, Central America & the Caribbean, South America, China & Mongolia, East Asia Low Income Countries, East Asia High Income Countries, Japan, South Asia, Ex-CPEs, Nordic Countries, Western Europe, Australia & New Zealand, The Pacific.

Table 3. The models and statistics for each country group

Area	Models and statistics	R^2	F
Africa & the Near East			
Indian Ocean	$Y= a + b X_1$		
	(11.7 11.5)	0.85	131.6
Near East	$Y= a + b T$		
	(15.0 10.9)	0.83	118.7
North Africa	$Y = a + b X_1+cT$		
	(0.4 3.3 13.9)	0.97	319.9
Sub-Saharan Africa	$Y = a + bX_1 + cX_2$		
	(1.6 6.7 8.3)	0.77	39.2
Asia			
China & Mongolia	$Y = a + bT$		
	(0.41 8.1)	0.73	65.7
East Asia HI countries	$Y = a + bT$		
	(55.2 23.2)	0.96	538.2
East Asia LI countries	$Y = a + bT$		
	(55.7 6.2)	0.61	38.2
Japan	Y = 10-year average		
South Asia	$\ln(Y) = a + b\ln(X_1)$		
	(-3.6 7.9)	0.72	62.7
Europe			
Ex-CPEs	$\ln(Y) = a + b \ln(X_1)$		
	(1.8 3.3)	0.43	10.7
Nordic Countries	$Y = a + bT$		
	(150.9 15.4)	0.91	236.2
Western Europe	$Y = a + bT$		
	(40.1 8.7)	0.76	75.5
Latin America			
Central America & the Caribbean	$Y = a + bX_1 + cD$		
	(-0.5 2.8 2.8)	0.87	77.5
South America	$Y = a + bT$		
	(26.7 3.4)	0.32	11.5
North America	$Y = a + bT$		
	(34.4 14.8)	0.90	218.8
Oceania			
Australia & New Zealand	$Y = a + bX_1 + cT$		
	(1.1 0.5 1.4)	0.85	66.6
Pacific	Y= 20-Year average		

Where: Y stands for *per caput* fish consumption;

X_1 is *per caput* GDP;

T is time trend with 1970=1;

D is a dummy variable used to model the structural change in the system;

a, b and c are estimated parameters;

Numbers in parentheses are the *t* statistics for estimated parameters.

or 87 million tonnes (Figure 11). In comparison with the last 35 years, the total demand increases more slowly, 216% vs. 110%.

The world average *per caput* demand in 2030 will amount to 22.5 kg per annum, increasing by 6.9 kg from the 1995 actual consumption level (15.6 kg) (Table 4). This represents a 44% increase over the next 35 years. In contrast, *per caput* consumption increased from 8.28 kg in 1961 to 15.6 kg in 1995, or a 88% increase over the 1961-1995 period (Table 4).

Table 4. Historical *per caput* fish consumption (kg) and potential demand forecasts

Historical per caput fish consumption								**Forecasted (kg)**		**Increase 1995-2030**	
Area/Year	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**2015**	**2030**	**%**	**Kg**
Indian Ocean	14.0	14.6	18.0	19.9	17.3	23.9	28.1	31.1	42.5	51.1	14.4
Near East	2.6	3.1	2.9	5.0	5.4	4.8	6.4	8.7	10.6	67.1	4.3
North Africa	3.0	2.6	3.9	5.0	6.4	7.2	8.4	12.7	17.9	112.3	9.5
Sub-Saharan Africa	6.1	7.3	8.3	8.6	7.7	8.9	7.6	10.8	15.6	105.2	8.0
Africa	**4.8**	**5.6**	**6.3**	**7.2**	**6.9**	**7.6**	**7.4**	**10.5**	**14.8**	**98.4**	**7.3**
China & Mongolia	4.3	3.8	4.8	4.4	6.7	10.7	22.2	26.0	34.3	54.7	12.1
East Asia HI countries	13.1	15.6	18.2	19.6	22.4	23.0	27.8	35.2	41.5	49.2	13.7
East Asia LI countries	18.7	19.7	20.9	19.7	22.0	23.8	22.8	26.5	28.6	25.7	5.9
Japan	52.4	63.5	70.6	65.5	69.5	71.2	70.9	70.9	70.8	-0.1	-0.1
South Asia	3.3	3.5	3.6	3.6	3.7	4.1	4.7	6.2	8.3	76.3	3.6
Asia	**8.5**	**9.2**	**10.2**	**9.7**	**11.2**	**13.0**	**17.9**	**20.1**	**24.1**	**34.7**	**6.2**
EX-CPEs	16.1	20.2	24.3	22.3	25.1	20.6	10.7	25.4	30.8	188.7	20.1
Nordic countries	27.9	30.8	31.7	32.4	32.5	34.0	35.6	38.8	41.7	17.2	6.1
Western Europe	18.2	18.4	17.4	17.4	19.9	22.2	22.1	26.7	30.1	36.4	8.0
Europe	**17.4**	**19.6**	**21.1**	**20.1**	**22.7**	**21.7**	**16.8**	**26.3**	**30.8**	**83.0**	**14.0**
Central America	4.9	5.7	6.5	9.6	9.4	10.2	8.3	15.5	25.8	208.9	17.4
South America	6.0	7.2	7.7	8.9	8.0	9.0	10.1	10.2	11.1	9.9	1.0
Latin America	**5.7**	**6.7**	**7.3**	**9.1**	**8.4**	**9.4**	**9.5**	**10.7**	**14.2**	**49.0**	**4.7**
North America	**12.8**	**14.4**	**14.0**	**15.5**	**19.4**	**21.4**	**21.6**	**30.0**	**35.5**	**64.0**	**13.9**
Australia & New Zealand	13.8	13.9	13.8	14.3	17.2	18.7	19.3	28.0	36.1	87.0	16.8
Pacific	16.2	19.5	20.5	26.8	29.0	28.1	20.0	25.5	25.5	27.3	5.5
Oceania	**14.3**	**15.0**	**15.2**	**17.0**	**19.9**	**20.9**	**19.5**	**27.5**	**33.2**	**70.6**	**13.7**
World Average	**9.9**	**10.8**	**11.6**	**11.4**	**12.6**	**13.6**	**15.6**	**18.7**	**22.5**	**44.3**	**6.9**

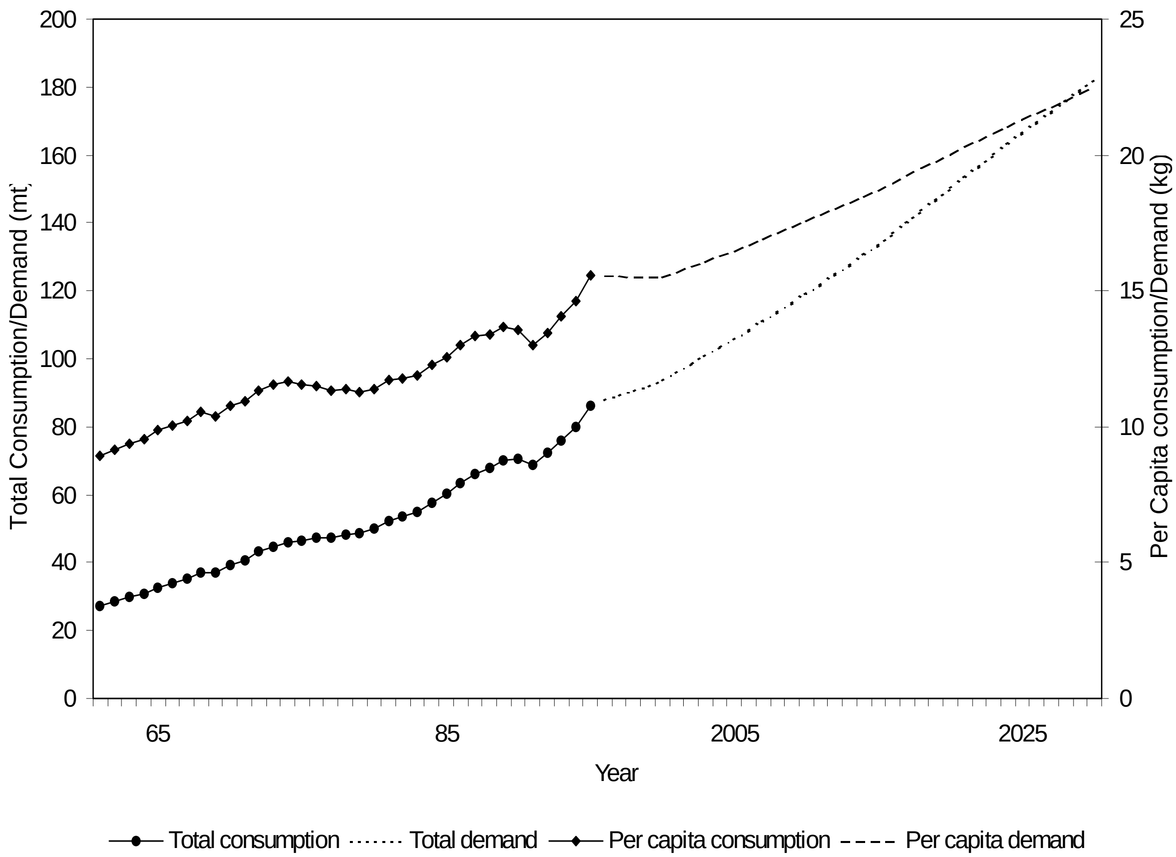

Figure 11. Historical fish consumption and future potential demand

If the increase in *per caput* demand is thought to be a result of economic development, the contribution of the increase in world population to the total demand for fish in 2030 can be assessed by multiplying the current *per caput* consumption with the increment in human population. Of the increase of 95 million tonnes, about 60%, or 56 million tonnes, will be caused by economic development and other factors, and about 40%, or 39 million tonnes, will result from the increase in population. If the world average *per caput* fish consumption was fixed at the 1995 level, the world total demand for fish and fishery products would be 126.5 million tonnes.

3.3 Regional differences in demand pressure

At the continental level, Africa will experience the fastest increase in *per caput* fish demand, or 98.4% from 1995 to 2030 (Table 4). Europe comes second, increasing by 83%. Oceanic area is predicted to increase by 80.3%, followed by North America and Latin America, 64% and 49%, respectively. Increase in fish demand in Asia will be the slowest, only 34.7% (Table 4).

However, Europe and North America will have the largest increase in *per caput* fish consumption, growing 14 kg and 13.9 kg, respectively, by 2030. Africa, Asia and Oceania have similar increments, 7.3 kg, 6.2 kg and 6.9 kg. The lowest increase will be seen in Latin America, only 4.7 kg (Table 4).

In terms of absolute volume of *per caput* demand, North America will be ranked first, 35.5 kg per annum in 2030, closely followed by Oceania and Europe, 33.2 kg and 30.8 kg, respectively. Asia is in the middle, 24.1 kg. The lowest demand for fish and fishery products will be seen in Latin America, only 14.2 kg per annum, and Africa exceeds Latin America slightly with 14.8 kg (Table 4).

The development of fish demand in the future also varies significantly within individual continents.

3.3.1 Africa

In Africa, the fastest increase will be seen in North Africa, 112.3% from 1995 to 2030 (Table 4). Sub-Saharan Africa will also increase by 105.2%. The slowest increase is in Indian Ocean, only 51.1%. Indian Ocean had the highest *per caput* fish consumption in history, 28.1 kg in 1995, and will still remain in the first place in this area, 42.5 kg in 2030 (Table 4). It is noteworthy that the differences between country groups will decrease in the future.

Near East Area had the lowest *per caput* fish consumption in the 1960s, and will remain at the bottom in comparison with other regional groups in Africa and the Near East, 10.6 kg in 2030 (Table 4). Its percentage increase is slightly higher than Indian Ocean, 67.1%.

3.3.2 Asia

Asia has the largest population and is also the largest fish producer and consumer. Japan is the most well known fish consuming country in the world, and one of the few countries where people consume more fish than meat. Its economic strength and strong desire for fish already helped its *per caput* consumption reach a saturation level of about 70 kg per annum, which has remained relatively stable over the last two decades. Historical data show that the daily animal protein intake was still increasing with the growth of GDP. The share of fish protein in total animal protein intake, however, has been decreasing gradually. The decreasing relative importance of fish in the Japanese diet may be caused by people's attitude. With the economic development and more open society, the influence of western culture and eating habits has become apparent. The western style food is relatively more meat oriented. The increased utilization of outside cooking services and simplification of cooking process may also contribute to the decreasing percentage share of fish in the Japanese total animal protein intake (Tassaka 1994, Westlund 1995).

With the assumption of saturation in Japan's fish consumption, the future demand for fish and fishery products are supposed to remain unchanged over the coming 35 years, and an average of *per caput* fish consumption over the last ten years were adopted.

The fastest increase in *per caput* fish consumption will be seen in South Asia, 76.3% by 2030 (Table 4). South Asia historically was a low fish consuming area. Its *per caput* consumption was only 4.7 kg in 1995, the lowest in the world and only 30% of the world average.

China experienced the rapidest development in fisheries. *Per caput* consumption increased 5 fold from 4.4 kg in 1980 to 22.2 kg in 1995 (Table 4). This increasing trend will still continue, but at a much lower rate. It was forecasted that *per caput* consumption would increase by 54.7% over the next 35 years, reaching 34.3 kg in 2030 (Table 4). China's population constitutes about 20% of the world population. With this increasing rate, China alone needs to increase its production by 24.3 million tonnes.

The high-income countries in East Asia will have a higher increasing rate than the low-income countries, 49.2% vs. 25.7% (Table 4). This will increase the gap between these two country groups. In the 1960s, people in the high-income countries consumed less fish than those in the low-income countries. *Per caput* fish consumption increased more rapidly in the high-income countries and exceeded that in the low-income countries by 5 kg in 1995 (Table 4). This gap will expand further with the increasing disparity in economic development between them.

3.3.3 Europe

Ex-CPEs was one of the few regions that experienced a dramatic decrease in *per caput* fish consumption over the last five years, from 20.6 kg in 1990 to 10.7 kg in 1995 (Table 4). This setback was mainly caused by the collapse of the former centrally planed economies. Such economic difficulties in the transitional period should not last for a long time. In long term, the former possible influence of economic factors on fish consumption would resume. Therefore, the demand forecast model for Ex-CPEs was fitted using only the historical data before their economic collapse.

In Europe, fish demand in the Ex-CPEs will have the fastest increase of 188.7% (Table 4). It is worthy mentioning that this figure was derived by comparing the 2030 demand with the consumption of 1995 when the collapsed economy reduced the fish consumption to an extremely low level of 10.7 kg, only 43% of its peak consumption, 25.1 kg, in 1985. In 2030, *per caput* consumption will reach 30.8 kg (Table 4), only 20% increase compared with its peak.

Nordic countries have the slowest increase in fish consumption, only 17.2% (Table 4). Nordic people had the highest fish consumption in Europe, 35.5 kg in 1995, but these are mainly meat consumption countries. Net export from this area reached 2.5 million tonnes, 48% of its total annual production. With the arising awareness of nutritional values of fish and fishery products, fish consumption is expected to increase by a modest rate in the future.

Western Europe will see an increase of 36.4% in *per caput* consumption by 2030. Its actual consumption per person will be 30.1 kg, very close to the Ex-CPEs (Table 4).

3.3.4 Latin America

In Latin America, Central America and the Caribbean will increase its fish consumption 3 fold from 8.3 kg in 1995 to 25.8 kg in 2030 (Table 4). This is the largest increase among the regions.

In contrast, South America has only an increase of 10% by 2030. This may reflect the fact that *per caput* fish consumption in this area fluctuated between 7 kg and 10 kg over the last thirty years. GDP also remained quite stable at the level of US$ 2000 per person.

3.3.5 North America

North America had the highest *per caput* fish consumption at the country group level, 21.6 kg in 1995. It will increase by 64%, reaching 35.5 kg in 2030 (Table 4). Although fish consumption is still low compared with meat consumption in this area, which was 113.5 kg per person in 1990, its share in animal protein intake increased slightly with the perception of fish as healthy food growing stronger (Westlund 1995).

3.3.6 Oceania

In the Oceanic area, *per caput* fish consumption in Australia and New Zealand will increase by 87%, reaching 36.1 kg in 2030 (Table 4). Pacific countries have experienced a decline in *per caput* fish consumption over the last ten years. It was expected that the decreasing trend would stop. For the period up to 2030, these countries' future demand was supposed to remain at the average level of the last 20 years, or 25.5 kg.

4. DISCUSSION

The World Fish Demand Model projects the evolution of the world demand for fish and fishery products over the next 35 years. It is extremely important to clearly understand what the forecasted demands mean. The forecast of the world demand for fish is a potential demand, not a consumption (materialized) forecast. The consumed amount of fish is the intersection between market demand and supply. As one side of the market, demand is only potential; the extent to which it becomes a materialized consumption depends on price. Because of the absence of data on prices, this study was unable to forecast the demand at the intersection of demand and supply. All the forecasts should also be viewed as potential demand that can be altered by production limitations and other economic factors. The data used for the forecasts were fish consumption observations.

The unique characteristic of fish production-marketing system is that materialized (short-run) demand is defined by the predetermined supply level because production cannot respond immediately to changes in price. Given the potential demand, when the predetermined supply is low, the price is high, and the actual or realized demand is low. When the predetermined supply is high, the price is low, and the actual or realized demand is high. In both cases, the short-run demand is controlled by the predetermined supply level through market prices. This demand is the achieved demand that is also called consumption. To forecast the materialized demand, price information is a prerequisite. Unfortunately, projecting price evolution may be even more difficult than forecasting demand itself. In the absence of the price effects in the model, the demand forecasts can only mean demand potentials, and the extent to which it can be realized depends on price, or, for fishery products, on production. In summary, the WFDM forecast is a forecast of potential demand, not of consumption. The extent to which the forecasted demand can be materialized depends on whether production can evolve with the same pattern as was seen in the past.

The treatment of expectations in econometric models has been an area of considerable controversy. The main alternative to assuming that expectations are forward looking and model consistent is to base the specification of expectations on backward-looking regressions of relevant variables on historical values of themselves and other variables. Most models incorporate a mixture of the two extremes, but typically with a strong inclination toward one extreme or another (Boucekkine 1995).

It should be emphasized that the projections made in this study are not simply the results of econometric equations. Adjustments are involved in complementing econometric projections in some cases. These adjustments are derived from a variety of sources both inside and outside FAO and represent the qualification of expert opinion on a large number of issues that cannot be modeled fully econometrically. This is especially the case when an econometric model gives nonsense results. For example, econometric results alone would indicate a much stronger increase of fish demand in China. The limited natural resources are unlikely to keep the Chinese fishery production at the current increasing rate for a long time period. Although a statistically significant relation could be found between *per caput* fish consumption and *per caput* GDP, time trend regression was instead used.

Although this study used only fish consumption, population and GDP, a great many uncertainties still surround future demand forecasts for fish and fishery products, especially those that look ahead as far as twenty to thirty years. The main sources of these uncertainties range widely and include:

<u>Economic output and structure.</u> Projections of economic growth vary considerably, especially for developing countries. In the transition economies of the former Soviet Union and East and Central Europe, the pace of economic restructuring and the adoption of market economies are uneven, especially for major industrial sectors, and their future is uncertain.

<u>Population growth</u>. The human history shows that population growth is related to economic development. The extent of such an economic influence, however, is difficult to assess. The downward revision in the world population forecast made in October 1996 by the United Nations may well prove that a great uncertainty is foreseeable in population growth, particularly when the projection goes into the future for as far as 30 years.

<u>Human attitudes and behavior.</u> As income rises, the demand for fish and fishery products probably increase, but is also possible to drop. In high-income countries, the recognization of fish as healthy food may attract more human consumption from animal protein to fish and fishery products. However, some saturation in fish consumption in some high-income countries may appear in the near future, most likely in Japan and the Nordic countries. The extent and timing of these possible changes are uncertain.

<u>Development of substitutes in the future.</u> The future demand for fish and fishery products also greatly depends on the development of substitutes for fish, for example red meat and poultry. Improvements of the supply of these substitutes or drop in costs of producing them may shift the market demand away from fish. The European Community’s Common Agriculture Policy is foreseen to change to reduce grain prices and subsequent livestock production costs. As poultry and pork in some countries are preferred food products, it seems likely that consumers will eat less fish than they would in the absence of a modified Common Agriculture Policy (FAO Fisheries Department 1998).

<u>Fishery subsidies.</u> In many countries, especially in developed countries, fishermen are subsidized by government. This indirectly reduces the production costs of fish and fishery products.

Changes will be necessary to make the supply industries financially viable. But, the timing of these changes are unknown and their effects on fish consumption are difficult to estimate.

This study focused on food fish, which is the total fishery production deducted by the amount of fish used for non-food purposes. The non-food fishery production mainly comes from natural fisheries. It has been a common knowledge now that the capacity of natural production is limited. With the increasing demand for human consumption, the supply constraints may result in reduction of non-food uses. The past history has demonstrated such a declining trend in the share of non-food uses in the total fishery production (Figure 5). With the development of processing technology, the percentage of non-food uses is expected to decline further in the future.

Another potential source for increasing natural food fish supply may be bycatches. It was reported that 17.9 to 39.5 million tonnes of fish are discarded annually from commercial fisheries, representing 20% of the total marine harvest (Alverson et al. 1994). The increasing demand for human fish consumption may promote the advance of bycatch processing technology and, consequently, the retention and processing of bycatches becomes economically viable (Andrew and Pepperell 1992). The bycatch that are now discarded at sea will then become a supply source of food fish.

5. REFERENCES

Ahmed, M. 1997. Fish for the poor under a rising global demand and changing fishery regime. Naga, The ICLARM Quarterly, July-December (Supplement): 73-76.

Alverson, D. L., Murawski, S. A. and Pope, J. G. 1994. A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper No. 339, pp 233.

Andrew, N. L. and Pepperell, J. G. 1992. The bycatch of shrimp trawl fisheries. Oceanogr. Mar. Biol. Annu. Rev. 30: 527-565.

Bell, F. W. 1986. The Pope and the price of fish. American Economic Review 58(15): 1346-50.

Bird, P. J. W. N. 1986. Econometric estimation of world salmon demand. Marine Resource Economics 3(2): 169-182.

Boucekkine, R. 1995. An alternative methodology for solving nonlinear forward-looking models. Journal of Economic Dynamics and Control. 19(4): 11-34.

Delagado, C. L. and McKenna, A. A. 1997. Demand for fish in sub-Saharan Africa: the past and the future. Naga, The ICLARM Quarterly, July-December (Supplement): 79-84.

DeVorentz, D. 1982. An econometric demand model for Canadian salmon. Canadian Journal of Agriculture Economics, 30(March 1982): 49-60.

FAO. 1996. Yearbook of fishery statistics: commodities. Vol. 83, pp179.

FAO. 1997. Review of the state of world fishery resources: marine fisheries. FAO Fisheries Circular No. 920, pp173.

FAO. 1998. The state of food and agriculture. FAO, Rome Italy, pp371.

FAO. Fisheries Department. 1998. The state of world fisheries and aquaculture. FAO, Rome, Italy, pp112.

Fox, K. A. 1992. Structural analysis and the measurement of demand for farm products. In S. R. Johnson, J. K. Sengupta and E. Thorbecke (ed), Demand analysis, econometrics and policy models. Iowa State University Press, USA, pp345.

Huang, K. S. 1988. An inverse demand system for U.S. composite foods. American Journal of Agricultural Economics, November Issue: 902-909.

Kent, G. 1987. Fish, food and hunger. The potential of fisheries for alleviating malnutrition. Westview Special Studies in Ocean Science and Policy, pp187.

Laureti, E. 1998. Fish and fishery products-world apparent consumption statistics based on food balance sheets (1961-1995). FAO Fisheries Circular No. 821 Revision 4, pp253.

Tassaka, Y. 1994. Current trends in fishery product consumption in Japan and the future outlook (FAO Working Paper/project GCP/INT/589/JPN).

Westlund, L. 1995. Apparent historical consumption and future demand for fish and fishery products-exploratory calculations. A Document for the International Conference on Sustainable Contribution of Fisheries to Food Security held in Kyoto, Japan in December 1995, pp36.

Ye, Y. 1994. Bioeconomic analysis of the harvesting of fishery resources. Ph. D. thesis. Imperial College, University of London, UK, pp296.

Ye, Y. 1996a. Market demand and supply potential of Chinese fish products. Asian Fisheries Science 9: 69-85.

Ye, Y. 1996b. Bioeconomic interactions between the capture fishery and aquaculture. Marine Resource Economics 11:105-123.

Annex I

List of Country Groups

Africa and the Neat East

Indian Ocean
Comoros
Mauritius
Reunion
Seychelles

Near East and the others
Afghanistan
Bahrain
Cyprus
Gaza Strip
Iran
Iraq
Israel
Jordan
Kuwait
Lebanon
Malta
Oman
Qatar
Saudi Arabia
Syria
Turkey
United Arab Emerates
Yemen

North Africa
Algeria
Egypt
Libya
Morocco
Tunisia

Su-Saharan Africa
Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cape Verde
Central African Republic
Chad
Congo
Côte d'Ivoire
Djibouti
Equatorial Guinea
Ethiopia and Eritrea
Gabon
Gambia
Ghana
Guinea
Guinea Bissau
Kenya
Lesotho
Liberia
Madagasgar
Malawi
Mali
Mauritania
Mozambique
Namibia
Niger
Nigeria
Rwanda
St Helena
Sao Tome and Principe
Senegal Sierra Leone
Somalia
South Africa
Sudan
Swaziland
Tanzania
Togo
Uganda
Zaire
Zambia
Zimbabwe

Asia

China and Mongolia

Annex I (cont.)

East Asia high income countries

Brunei Darussalaam
Hong Kong
Indonesia
Korea Republic
Malaysia
Singapore
Thailand
Taiwan (province of China)

East Asia low income countries

Cambodia
Korea DPR
Laos
Macau
Myanmar
Philippines
Viet Nam

Japan

South Asia

Bangladesh
Bhutan
India
Maldives
Nepal
Pakistan
Sri Lanka

Europe

Ex-CPEs

Albania
Armenia
Azerbaijan
Belarus
Bosnia Herzegovina
Bulgaria
Croatia
Czech Republic
Estonia
Georgia
Hungary
Kazakhstan
Krygyzstan
Latvia
Lithuania
Macedonia
Moldova
Poland
Romania
Russia
Slovakia
Slovenia
Tajikstan
Turkemenistan
Ukrane

Nordic countries

Faeroe Islands
Finland
Iceland
Norway
Sweden

Western Europe

Austria
Belgium-Luxembourg
Denmark
France
Germany
Greece
Ireland
Italy
Netherlands
Portugal
Spain
Switzerland
United Kingdom

Latin America

Central America and the Caribbean

Antigua and Barbuda
Aruba
Bahamas

Annex I (cont.)

Barbados
Belize
British Virgin Islands
Cayman Islands
Costa Rica
Cuba
Dominica
Dominica Republic
El Salvador
Grenada
Guadeloupe
Guatemala
Haiti
Honduras
Jamaica
Martinique
Mexico
Montserrat
Netherlands Antilles
Nicaragua
Panama
Puerto Rico
St Kitts and Nevis
St Lucia
St Vincent
Trinidad and Tobago
Turks and Caicos Islands
US Virgin Islands

<u>South America</u>

Argentina
Bolivia
Brazil
Chile
Colombia
Ecuador
Falkland Islands
French Guinea
Guyana
Paraguay
Peru
Surinam
Uruguay
Venezuela

<u>North America</u>

Bermuda
Canada
Greenland
St Pierre and Miquelon
USA

<u>Oceania</u>

<u>Australia and New Zealand</u>

<u>Pacific</u>

American Samoa
Cook Island
Fiji
French Polynesia
Guam
Kiribati
Marshall Islands
Micronesia
New Caledonia
Niue
Northern Mariana Islands
Palau
Papua New Guinea
Samoa
Solomon Islands
Tonga
Tuvalu
Vanuatu
Wallis and Futuna Islands

Annex II

List of the Low-Income Food-Deficit Countries

Africa and the Near East

Afghanistan
Benin
Burkina Faso
Burundi
Cameroon
Cape Verde
Central African Republic
Chad
Comoros
Congo, Democratic Republic
Congo, Republic
Côte d'Ivoire
Djibouti
Egypt
Equatorial Guinea
Eritrea
Ethiopia
Gambia
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Madagascar
Malawi
Mali
Mauritania
Morocco
Mozambique
Niger
Rwanda
Sao Tome and Principle
Sénégal
Sierra Leone
Somalia
Sudan
Swaziland
Tanzania
Togo
Zambia

Asia

Bangladesh
Bhutan
Cambodia
China
India
Indonesia
Korea, Dem. Peop. Rep.
Laos
Maldives
Mongolia
Nepal
Pakistan
Philippines
Sri Lanka
Syria
Yemen

Latin America

Bolivia
Cuba
Ecuador
Guatemala
Haiti
Honduras
Nicaragua

Europe

Albania
Armenia
Azerbaijan
Bosnia and Herzegovina
Georgia
Krygyzstan
Macedonia
Tajikistan
Turkmenistan

Oceania

Kiribati
Papua New Guinea
Samoa
Solomon Islands
Tokelau
Tuvalu
Vanuatu